

Application No. 09/894,090  
Amendment Dated March 29, 2004  
Reply to Office Action of January 29, 2004

### **AMENDMENTS TO THE CLAIMS:**

This listing of claims replaces all prior versions and listings of claims in the application:

### **LISTING OF THE CLAIMS**

1. (currently amended) A database management system (DBMS) for managing a database application, the database application including a database having at least one table, and an index having at least one unique key index table corresponding to the at least one table, the DBMS comprising:

- a data manager for managing updates of the database;
- an index manager for managing updates of the unique key table index;
- a transaction manager for executing database transactions in cooperation with the data manager and the index manager; and,

- a lock manager cooperative with the index manager and the data manager for restricting access to a first table element of said at least one table by assigning one or more locks thereto, said locks being selected from a plurality of lock types including at least,

- an exclusive X-lock that enables exclusive access to the first table element, the exclusive X-lock including a Delete X-lock attribute logically associated therewith, a SET state of the Delete X-lock attribute being indicative of a transaction holding the X-lock being a delete transaction;

- an unconditional S-lock that enables shared access to the first table element and is selectively assigned by the lock manager to the first table element only when the first table element is without an exclusive X-lock previously assigned thereto; and

- a conditional S-lock that enables shared access to the first table element and is selectively assigned by the lock manager to the first table element only when the first table element is either without an exclusive X-lock previously assigned thereto or is without an exclusive X-lock having its Delete X-lock attribute SET assigned thereto.

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2. (canceled)

3. (previously presented) The DBMS as set forth in claim 1, wherein:  
the unique key index table further includes a pseudo-delete flag corresponding to each key entry of the unique key index table; and,  
the index manager selectively SETs the pseudo-delete flag to indicate deletion of a table row corresponding to the index key entry.

4. (original) The DBMS as set forth in claim 3, wherein in response to receiving a request from the index manager to enter an index key entry and a corresponding new row identification RID in which the index key entry corresponds to an existing index key entry whose pseudo-delete flag SET, the index manager is operative to:

request a Conditional S-lock on the table row corresponding to the existing index key entry; and,

conditional upon the Conditional S-lock on the table row corresponding to the existing index key entry being granted by the lock manager, update the table index key entry with the new row identification RID, release the Conditional S-lock on the table row corresponding to the existing index key entry, and reset the pseudo-delete flag to and OFF state.

5. (original) The DBMS as set forth claim 4, wherein in response to receiving a request from the index manager to enter an index key entry and a corresponding new row identification RID in which the index key entry corresponds to an existing index key entry whose pseudo-delete flag is SET, the index manager is adapted to:

conditional upon the Conditional S-lock on the table row corresponding to the existing index key entry being denied by the lock manager, request an unconditional S-lock on the table row corresponding to the existing index key entry; and,

upon granting of the unconditional S-lock by the lock manager, update the table index key entry with the new row identification RID, release the unconditional S-lock,

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and reset the pseudo-delete flag.

6. (original) The DBMS as set forth in claim 3, wherein in response to receiving a request from the index manager to enter an index key entry and a corresponding new row identification RID in which the index key entry corresponds to an existing index key entry whose pseudo-delete flag is NOT SET, RESET, or OFF, the index manager is operative to:

request an unconditional S-lock on the table row corresponding to the existing Index key entry; and,

upon granting of the unconditional S-lock on the table row corresponding to the existing index key entry by the lock manager and conditional upon the index key entry having its pseudo-delete flag SET, update the table index key entry with the new row identification RID, release the unconditional S-lock, and reset the pseudo-delete flag.

7. (currently amended) A database management method for entering a key and a new row identification RID into a unique key table index of a database application that uses pseudo-deletion of table index entries, comprising:

searching the unique key table index for the key;

when a pseudo-deleted table index entry corresponding to the key is located during the searching step:

requesting a Conditional S-lock on a table row indexed by the pseudo-deleted table index entry, said Conditional S-lock having compatibility characteristics respective to an X-lock including:

the Conditional S-lock not being compatible with an X-lock having a Delete attribute logically associated with the X-lock that is SET or ON, and

the Conditional S-lock being compatible with an X-lock having a Delete attribute logically associated with the X-lock that is NOT SET or OFF; and,

conditional upon receiving an indication that the Conditional S-lock is granted, updating the table index entry with the new row identification RID and resetting the pseudo-delete flag; and,

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conditional upon not locating a table index entry corresponding to the key during the searching step, updating the table index by adding the key and the new row identification RID.

8. (previously presented) The method according to claim 7, wherein the step of receiving an indication that the Conditional S-lock is granted includes the steps of:

granting the Conditional S-lock conditional upon the table row indexed by the pseudo-deleted table index entry not having an X-lock assigned thereto;

granting the Conditional S-lock conditional upon the table row indexed by the pseudo-deleted table index entry having an X-lock assigned thereto wherein said X-lock has its Delete attribute not set, reset, or off; and

receiving an indication that the Conditional S-lock is granted conditional upon the granting of the Conditional S-lock.

9. (original) The method according to claim 8, further including the steps: conditional upon receiving an indication that the Conditional S-lock is denied:

requesting an unconditional S-lock on the table row indexed by the pseudo-deleted table index entry; and

conditional upon receiving an indication that the unconditional S-lock is granted, updating the table index entry with the new row identification RID and resetting the pseudo-delete flag.

10. (canceled)

11. (currently amended) An article of manufacture comprising a program storage medium readable by a computer and embodying one or more instructions executable by the computer to perform method steps for entering a key and a new row RID into a unique key table index of a database stored on a data store connected to the computer, the unique key table index using pseudo-deletion of table Index entries, the method comprising the steps of:

searching the unique key table index for the key;

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conditional upon locating a pseudo-deleted table index entry corresponding to the key during the searching step:

requesting a Conditional S-lock on a table row indexed by the pseudo-deleted table index entry, said Conditional S-lock being incompatible with an X-lock acquired by a delete operation and being compatible with an X-lock not acquired by a delete operation, based on a Delete attribute logically associated with the X-lock, and

conditional upon receiving an indication that the Conditional S-lock is granted, updating the table index entry with the new row identification RID and resetting the pseudo-delete flag; and,

conditional upon not locating a table index entry corresponding to the key during the searching step, updating the table index by adding the key and the new row identification RID.

**12. (original)** The article of manufacture according to claim 11, wherein the step of receiving an indication that the Conditional S-lock is granted includes the steps of:

granting the Conditional S-lock conditional upon the table row indexed by the pseudo-deleted table index entry not having an X-lock assigned thereto;

granting the Conditional S-lock conditional upon the table row indexed by the pseudo-deleted table index entry having an X-lock assigned thereto wherein said X-lock has a Delete attribute that is not set, reset, or off; and

receiving an indication that the Conditional S-lock is granted conditional upon the granting of the Conditional S-lock.

**13. (original)** The article of manufacture according to claim 12, wherein the method further includes the steps, to be executed conditional upon receiving an indication that the Conditional S-lock is denied, of:

requesting an unconditional S-lock on the table row indexed by the pseudo-deleted table index entry; and

conditional upon receiving an indication that the unconditional S-lock is granted, updating the table index entry with the new row identification RID and resetting the

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pseudo-delete flag.

14. (canceled)

15. (currently amended) A lock manager for use in a database management system (DBMS) managing a database application including a database having at least one table and cooperative with an Index manager and a data manager for restricting access to a first table element of said at least one table by assigning one or more locks thereto including at least an exclusive X-lock that enables exclusive access to the first table element, the exclusive X-lock including a Delete attribute logically associated therewith, a SET state of the Delete attribute being indicative of a transaction holding the X-lock being a delete transaction.

16. (previously presented) The lock manager according to claim 15, wherein:

the lock manager is adapted to restrict access to said first table element by assigning a Conditional S-lock that enables shared access to the first table element and is selectively assigned by the lock manager to the first table element only when the first table element does not have an X-lock with its Delete attribute in a SET state assigned thereto.

17. (previously presented) The lock manager as set forth in claim 16, wherein:

the index manager manages a unique key index table that includes a pseudo-delete flag corresponding to each key entry of the unique key index table; and,  
the index manager is operative to selectively SET the pseudo-delete flag to indicate deletion of a table row corresponding to the index key entry.

18. (previously presented) The lock manager as set forth in claim 17, wherein:

in response to receiving a request from the transaction manager to enter an index key entry and a corresponding new row identification RID in which the index key

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entry corresponds to an existing Index key entry of the unique key index table whose pseudo-delete flag is SET, the Index manager is operative to request a Conditional S-lock on the table row corresponding to the existing index key entry; and,

the lock manager is operative to grant the Conditional S-lock on the table row corresponding to the existing index key entry being only when:

the table row is without an exclusive X-lock assigned thereto, or the table row has an exclusive X-lock assigned thereto with its Delete attribute not in said SET state, to enable the Index manager to update the table index key entry with the new row identification RID, release the Conditional S-lock on the table row corresponding to the existing index key entry, and reset the pseudo-delete flag to and OFF state.